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SOME MEASUREMENTS OF TERRAIN EFFECTS ON BLAST WAVES

M. L. Merritt, Division 5112

February 12, 1952

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SOME MEASUREMENTS OF TERRAIN EFFECTS ON BLAST WAVES

Summary. -- During Operation Buster some of the nearby hills were instrumented using pressure gauges in an attempt to explore the manner in which terrain features influence the propagation of blast waves. Because of loss of records from experimental difficulties and lack of duplication of gauges, results are, at best, fragmentary. The evidence on the protective effects of hills is inconclusive, but there is definite evidence of a change in a blast proceeding up the front of a hill.

Statement of the Problem

That terrain features, such as hills and valleys, influence the propagation of blast waves is evident from a study of damage done to Nagasaki. There damage was concentrated along a river valley and reached farther from the zero point than in the flat country about Hiroshima, while in areas sheltered by the hills to the southeast there was but little damage. Thus some idea has been obtained of the effects to be expected from irregularities of the earth's surface, but it is desirable to extend this qualitative start to the point where quantitative, though empirical, rules for prediction of damage can be formulated.

No evidence on terrain effects other than that from Japan is available. At a meeting of representatives from J-Division, Los Alamos Scientific Laboratory, and the Weapons Effect Department of Sandia Corporation on July 17, 1951, it was suggested that the time is ripe to begin exploration of the problem. Accordingly there was included in the joint blast effects program of the two agencies a project whose stated purpose was 'to explore the manner in which gross terrain features influence the propagation of blast waves.'

Planning for this project was undertaken by M. L. Merritt for the Corporation; instrumentation was done by the Corporation's Field Test Organization, 1630, and the actual work was done under the direction of W. A. Finchum.

Instrumentation and Layout

Limited time (approximately three months), coupled with its lesser importance compared with other tests under way, kept the terrain effects test on a very modest scale. The problem was to gain a maximum of information using about six gauge stations and relying only

on readily available equipment. Interferometer gauges[1] were chosen for this purpose; these gauges are self-recording onto film and require only start and timing signals. Diaphragms were available whose sensitivities were such (1/10 psi/fringe shift) that they could measure with an accuracy of 5 per cent pressures in the range 1/2 to 3 psi. Control circuits applicable to this use had been developed for the Jangle operation, and it was necessary only to increase quantities on order, particularly of batteries.

The already chosen ground zero dictated the terrain to be instrumented. Site T-7 lies about two miles from the hills bordering the Yucca Flat valley (Nevada test site) on the east; the under limit of accurately measurable pressures (1/2 psi) indicated that any area chosen should be within four miles of the shot point. The area chosen is a long draw, opening into the plain about 2-1/2 miles northeast of T-7; this draw is about 4000 feet wide at the opening and flanked by hills 300-500 feet high. From the entrance it looks like a large bowl in which the waterway curves off to the right and a space is set off behind an isolated hill to the left.

Instrumentation consisted of a control point and six instrument stations. At the control point was a motor generator for power and equipment to send start and time signals to the several instrument stations. At each of the instrument stations was an interferometer gauge, mounted with its sensitive area flush with the ground, and a bank of dry-cell batteries for the gauge itself.

The locations of the instrument stations were (Figs. 1-3): one (gauge station 5) well out in the open to determine the nature of the blast wave before it entered the area of interest; one (station 3) in the middle of the valley, one (station 2) at the head of the valley at the start of the slope, and one (station 1) well up the slope (stations 1, 2, and 3 followed the progress and change in character, if any, of the blast wave as it went up the valley); and two (stations 4 and 6) in the lee of a hill to the north to explore the shadow effect of the hill.

In Fig. 4 are shown profiles of the terrain over which a direct line must pass from shot point E to gauges 4 and 6 and from shot point E to gauges 5, 3, 2, and 1. It is not to be understood that the blast wave actually travelled these paths since they are not necessarily the paths of least transit time; for instance, the wave passing over the hill between the shot point and gauge 4 was very possibly bent around the sides of the hill as well as passing over the top, but these profiles are nevertheless indicative of the type of obstruction which the blast encountered and are presented as such.

Test Results

The number of usable records resulting was embarrassingly small. The yield from shot A was so small that the signal did not arrive when expected. In shot B the equipment failed to turn on because it received no signal at minus 5 minutes. In shot C the gauges were turned on late so that records from three of the six positions show only the negative phase of the blast. Experimental difficulties in shot D were such that three gauges did not turn on. In shot E, for some undetermined reason, no blast shows on the record from position 5. Added to all these misfortunes, timing marks do not appear on two of the records.

In all there were nine complete and five incomplete records (Table I). Complete or incomplete, fourteen sets of data are available. These are plotted as solid lines in Figs. 5-18; broken lines indicate predicted air pressures (see p 28). In the inserts details of the first 100 milliseconds of the pressure record are plotted to an expanded time scale.

TABLE I

Condition of records

Station	Shot C			Shot D			Shot E		
	Complete record	Negative only*	No timing marks	Complete record	Negative only*	No timing marks	Complete record	Negative only*	No timing marks
1	x			x			x		
2		x		No record			x		
3		x			x	x	x		
4		x		No record			x		x
5	x			x			No record		
6	x			No record			x		

*Positive phase missing.

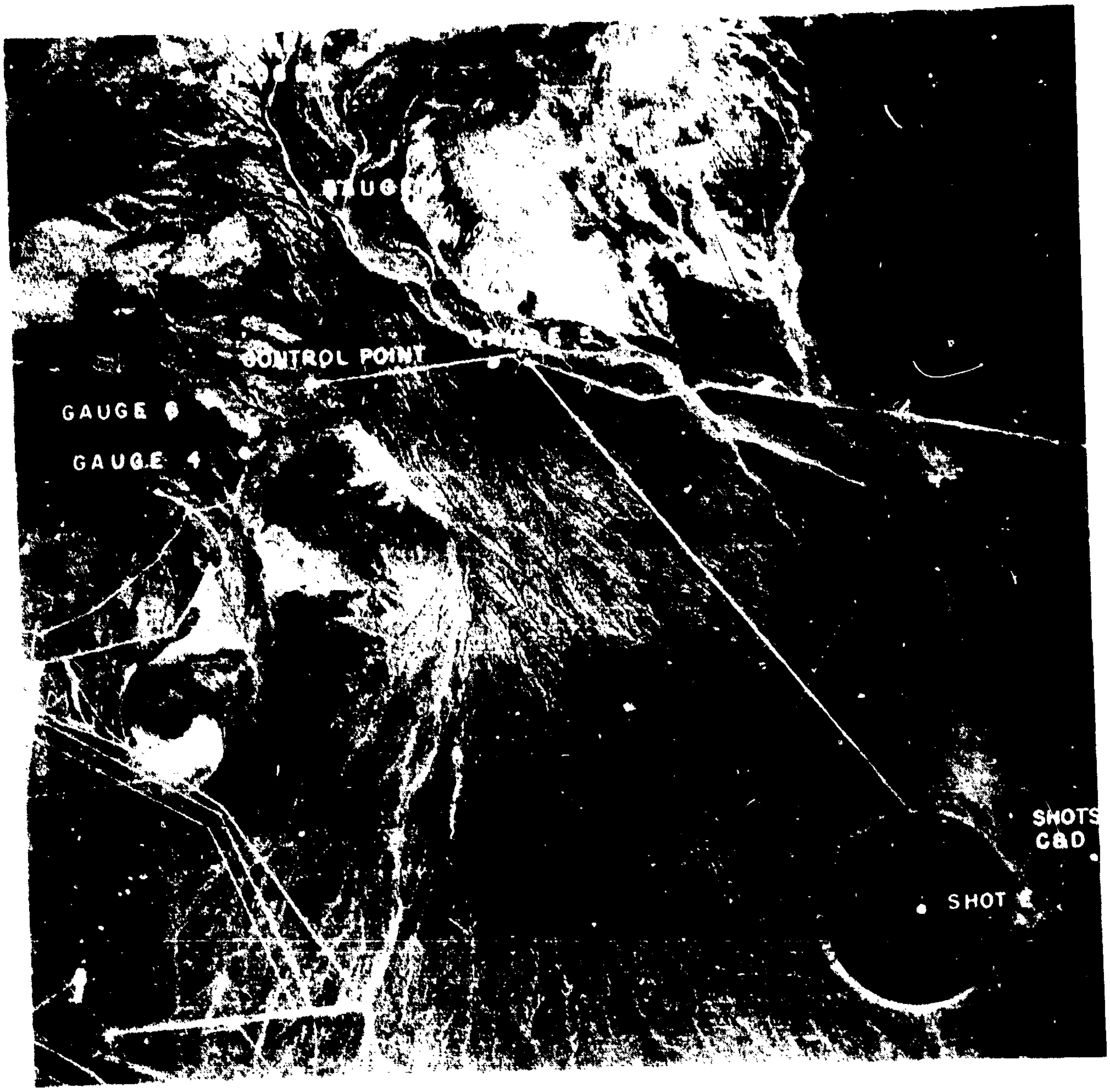
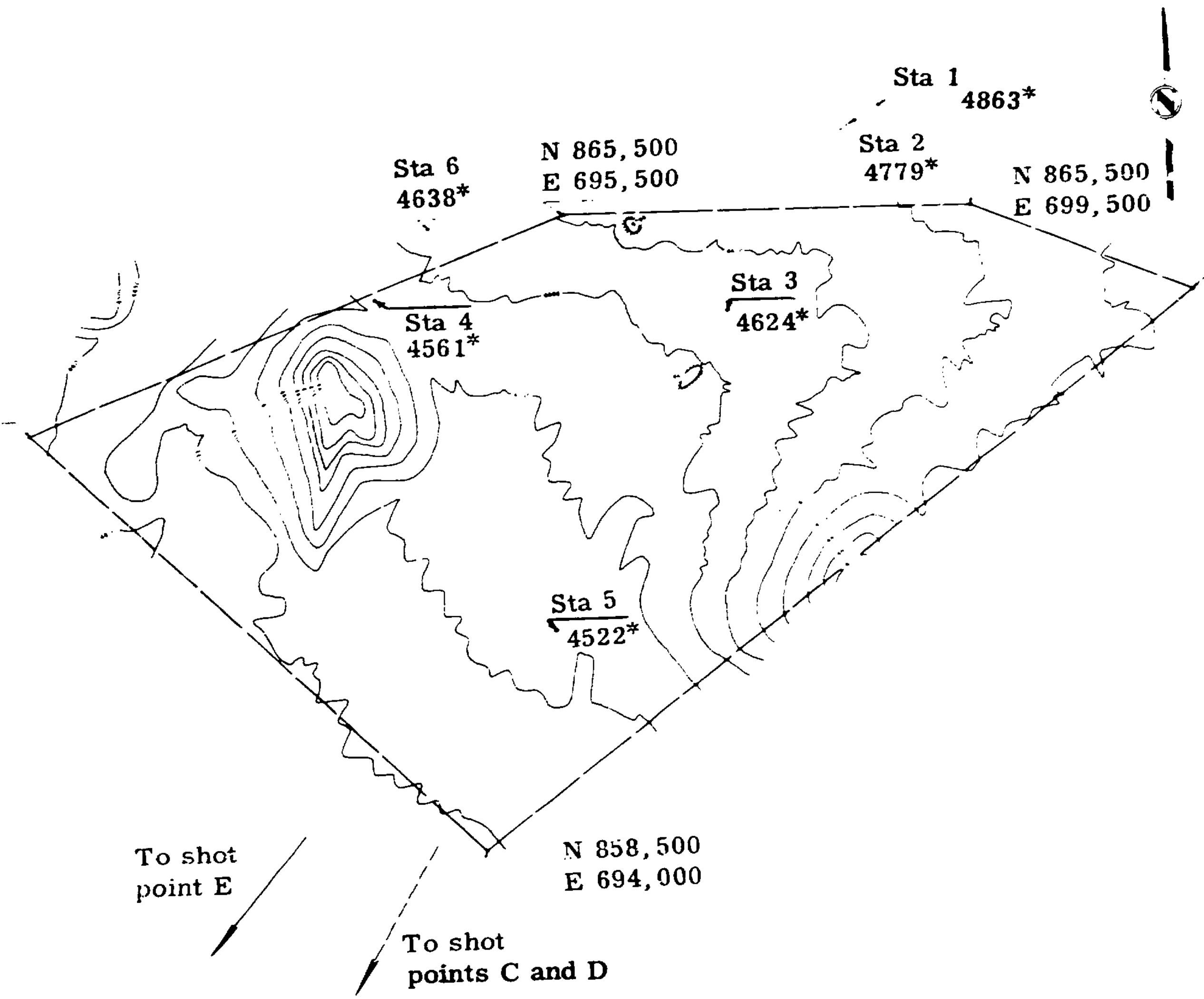


Fig. 1. -- Aerial view showing relation of test area to shot point

Fig. 2. -- Aerial view of test area



*Elevation

Fig. 3. -- Topographic sketch of test area

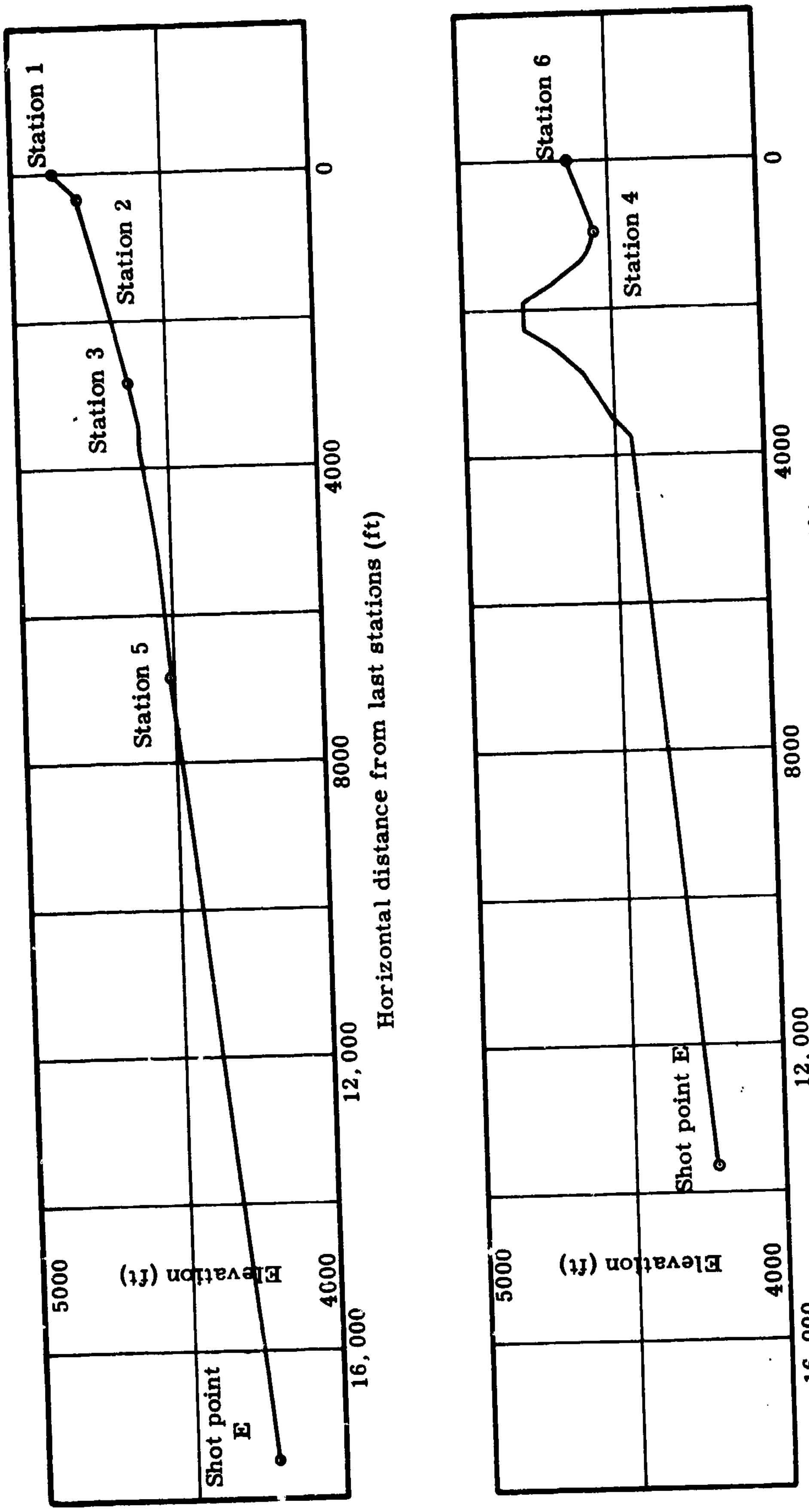


Fig. 4. -- Profiles of terrain between shot points and gauge stations

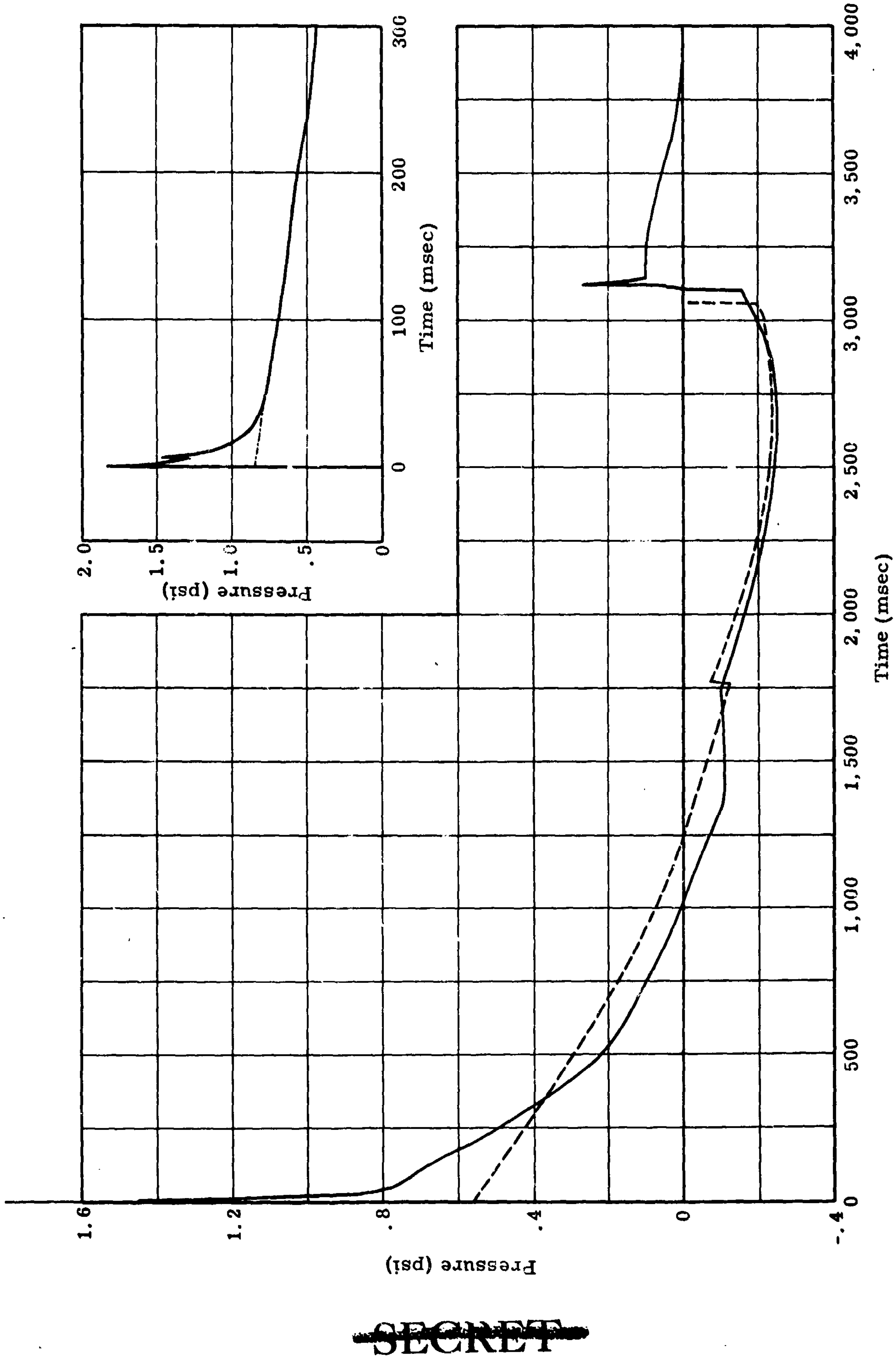


Fig. 5. -- Observed and predicted data from gauge 1 shot C

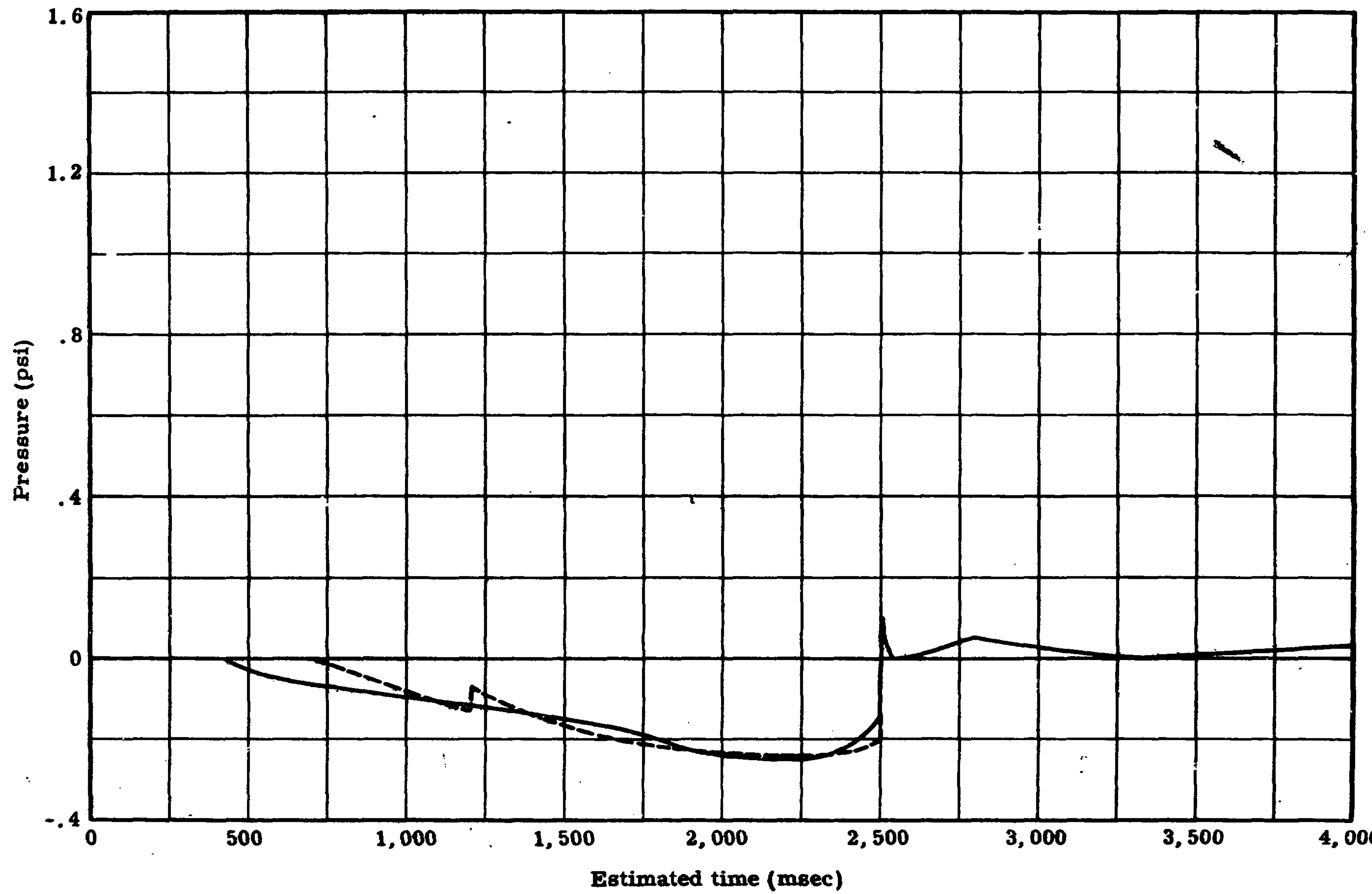


Fig. 6. -- Observed and predicted data from gauge 2 shot C

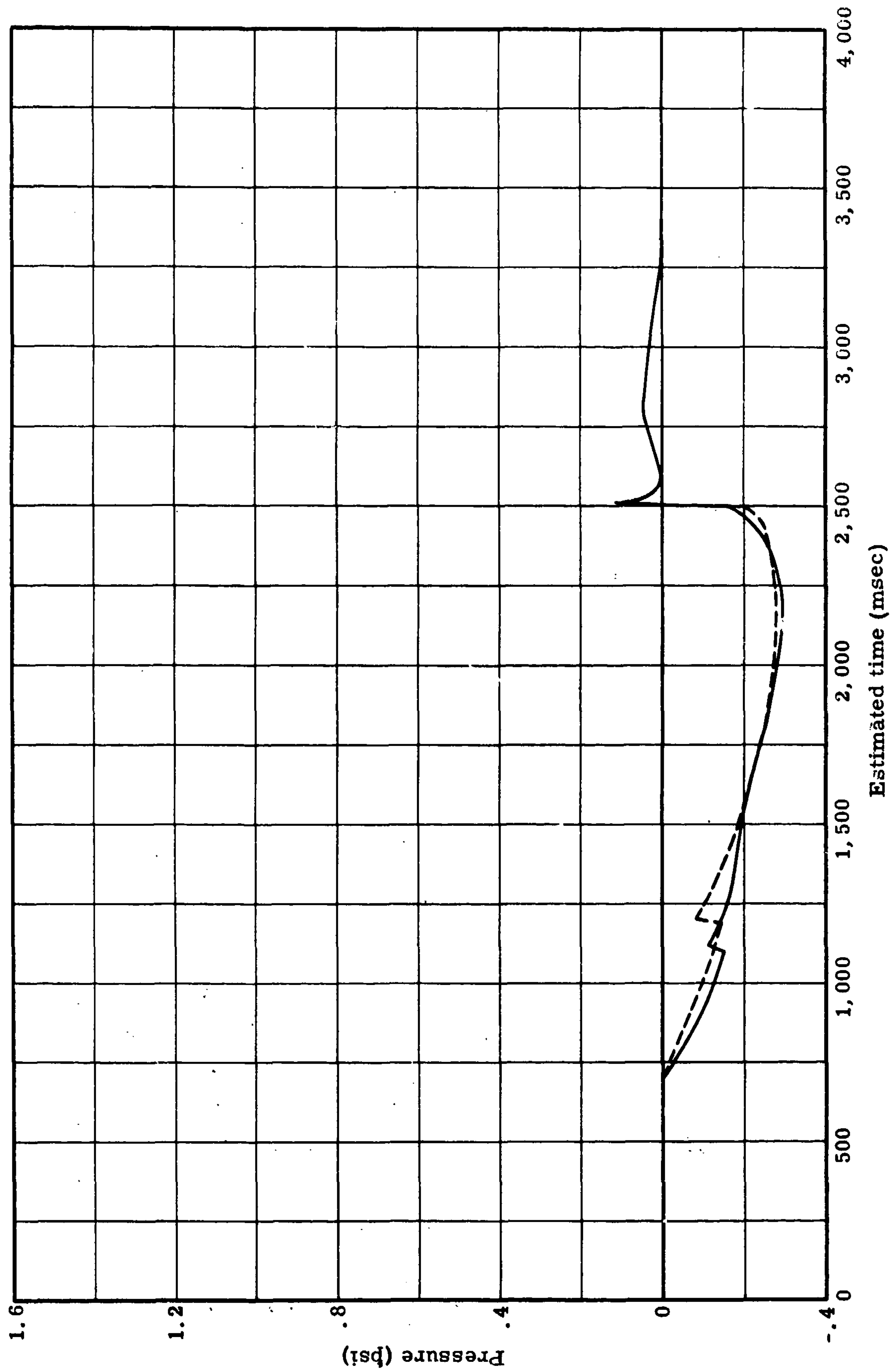


Fig. 7. -- Observed and predicted data from gauge 3 shot C

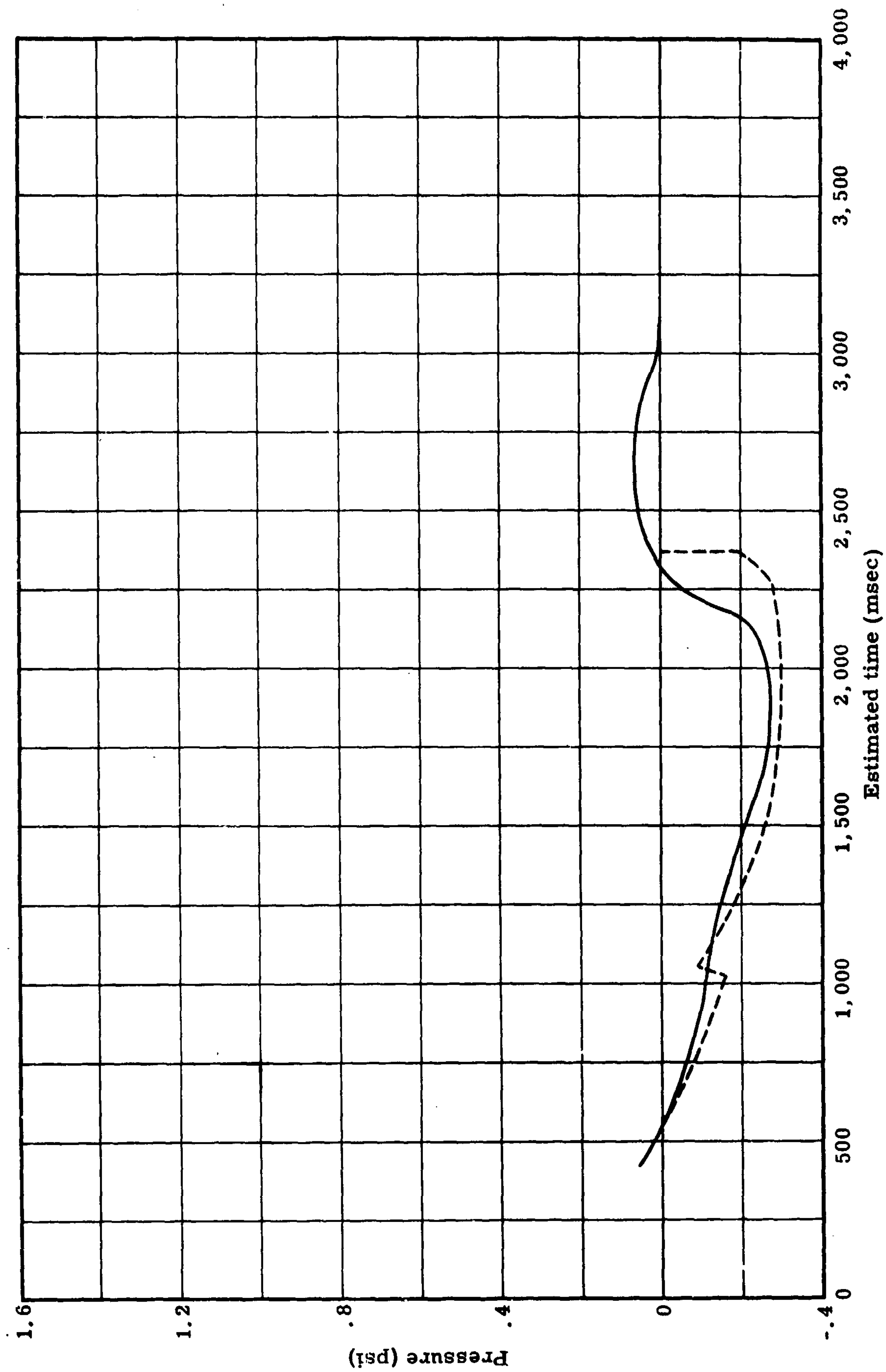


Fig. 8. -- Observed and predicted data from gauge 4 shot C

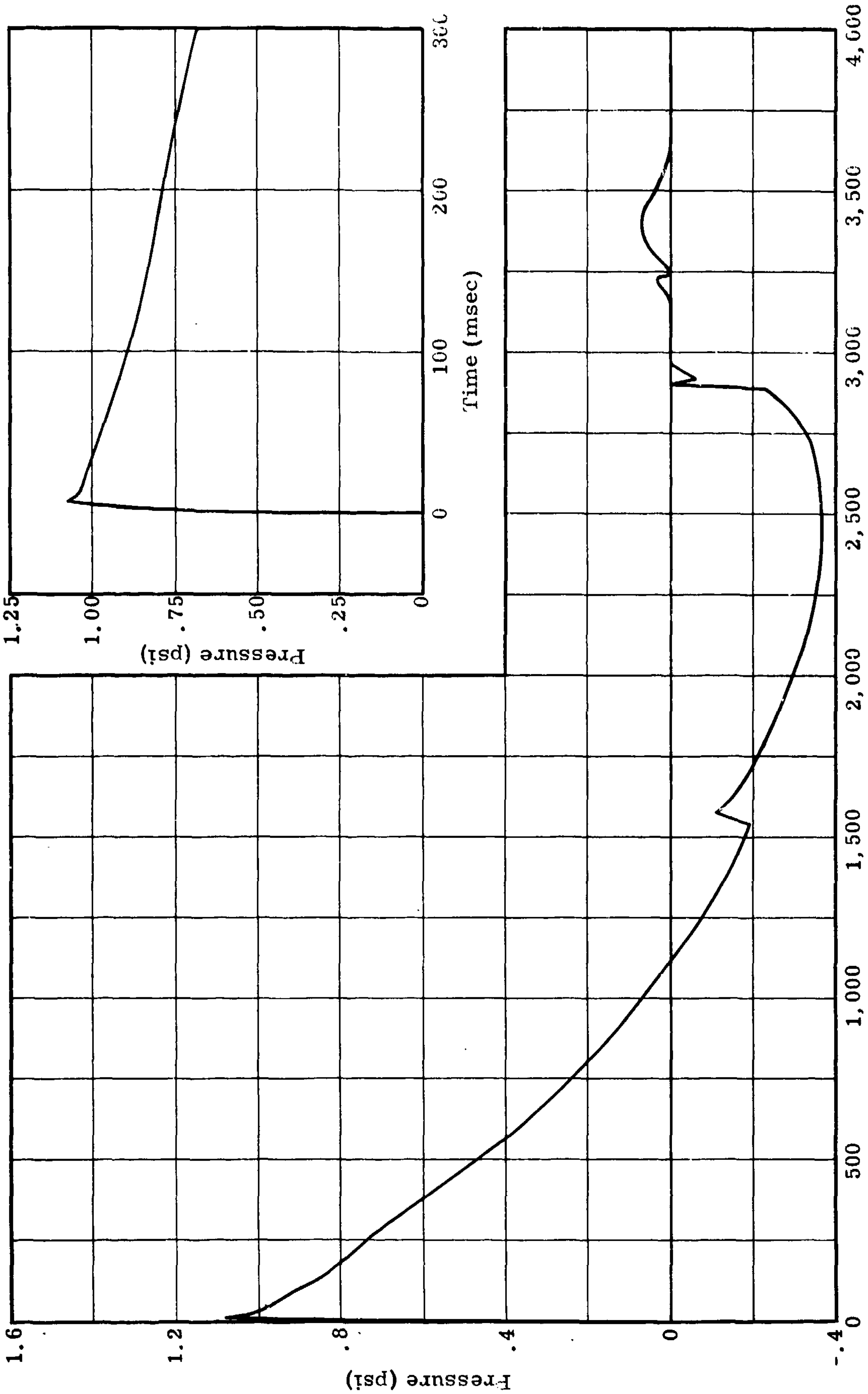


Fig. 9. -- Observed and predicted data from gauge 5 shot C

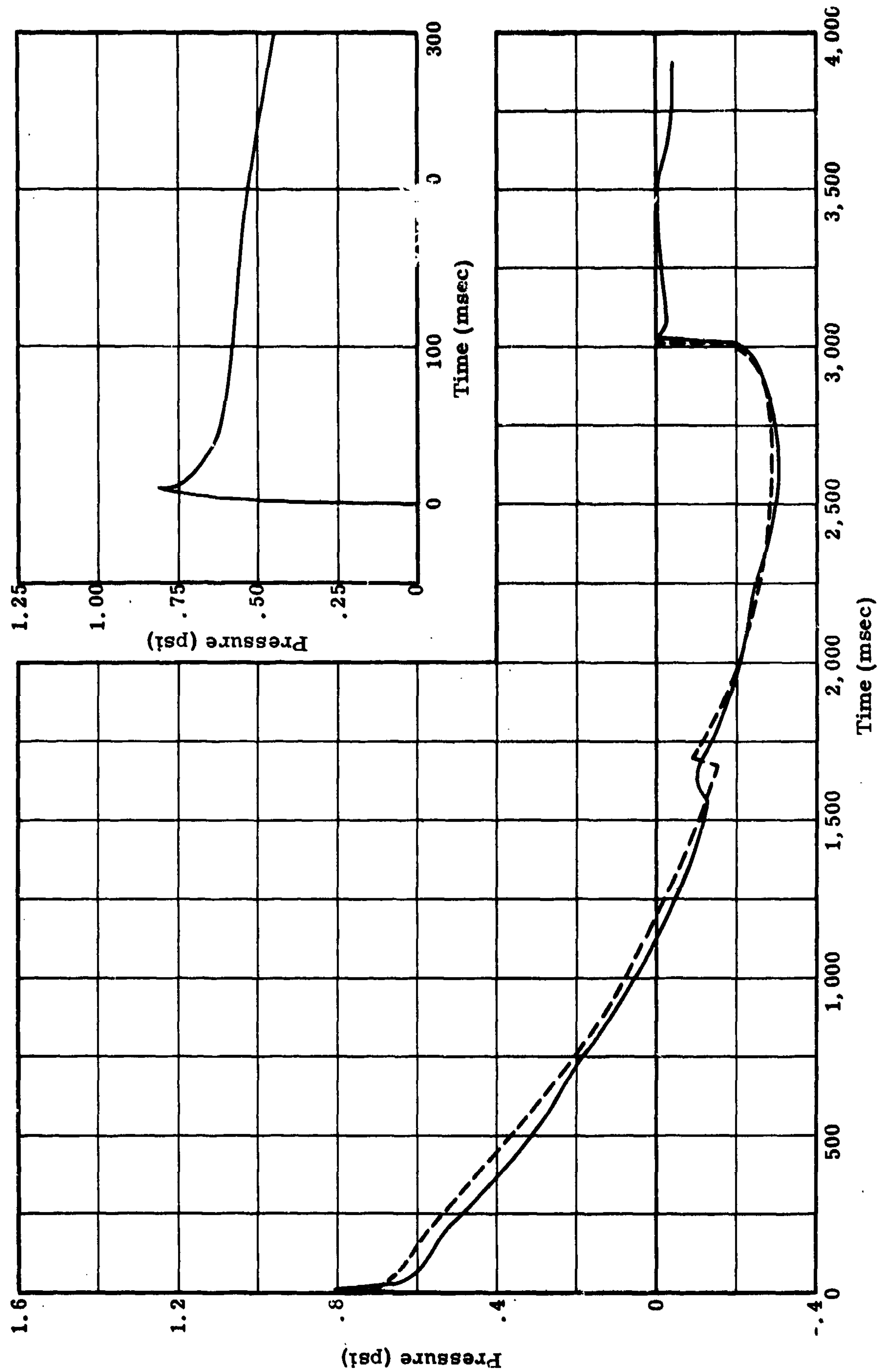


Fig. 10. -- Observed and predicted data from gauge 6 shot C

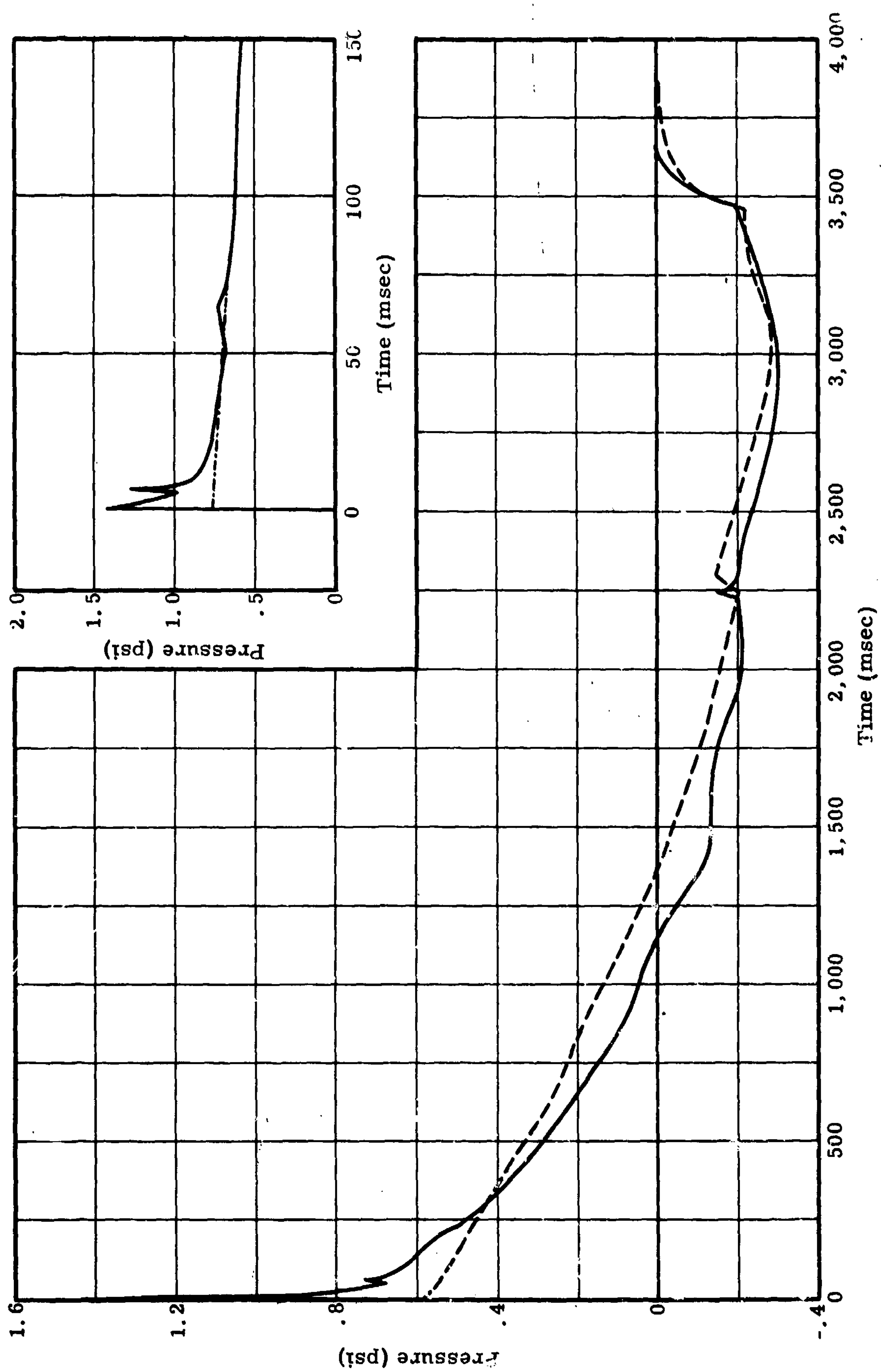


Fig. 11. -- Observed and predicted data from gauge 1 shot D

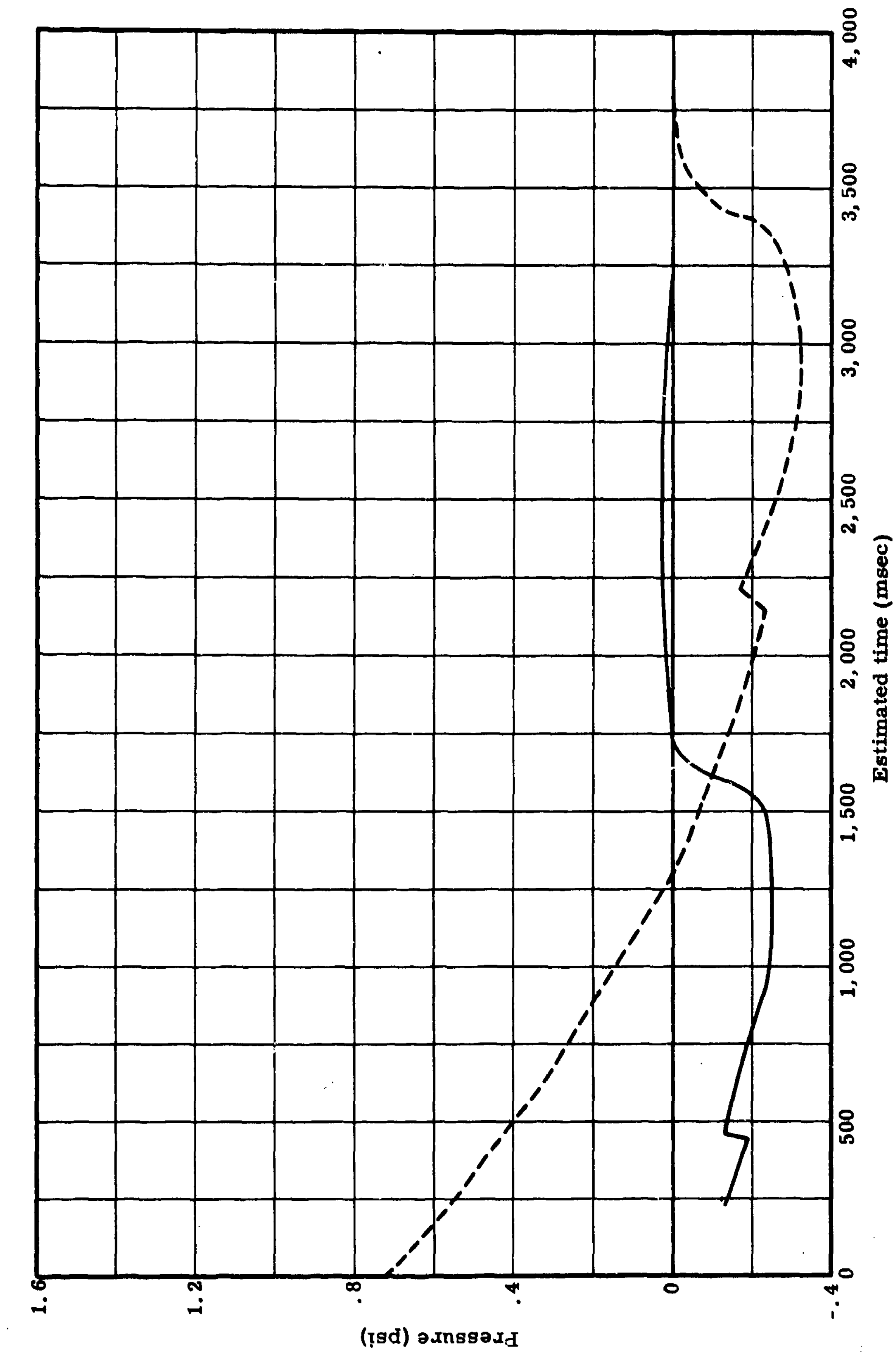


Fig. 12. -- Observed and predicted data from gauge 3 shot D

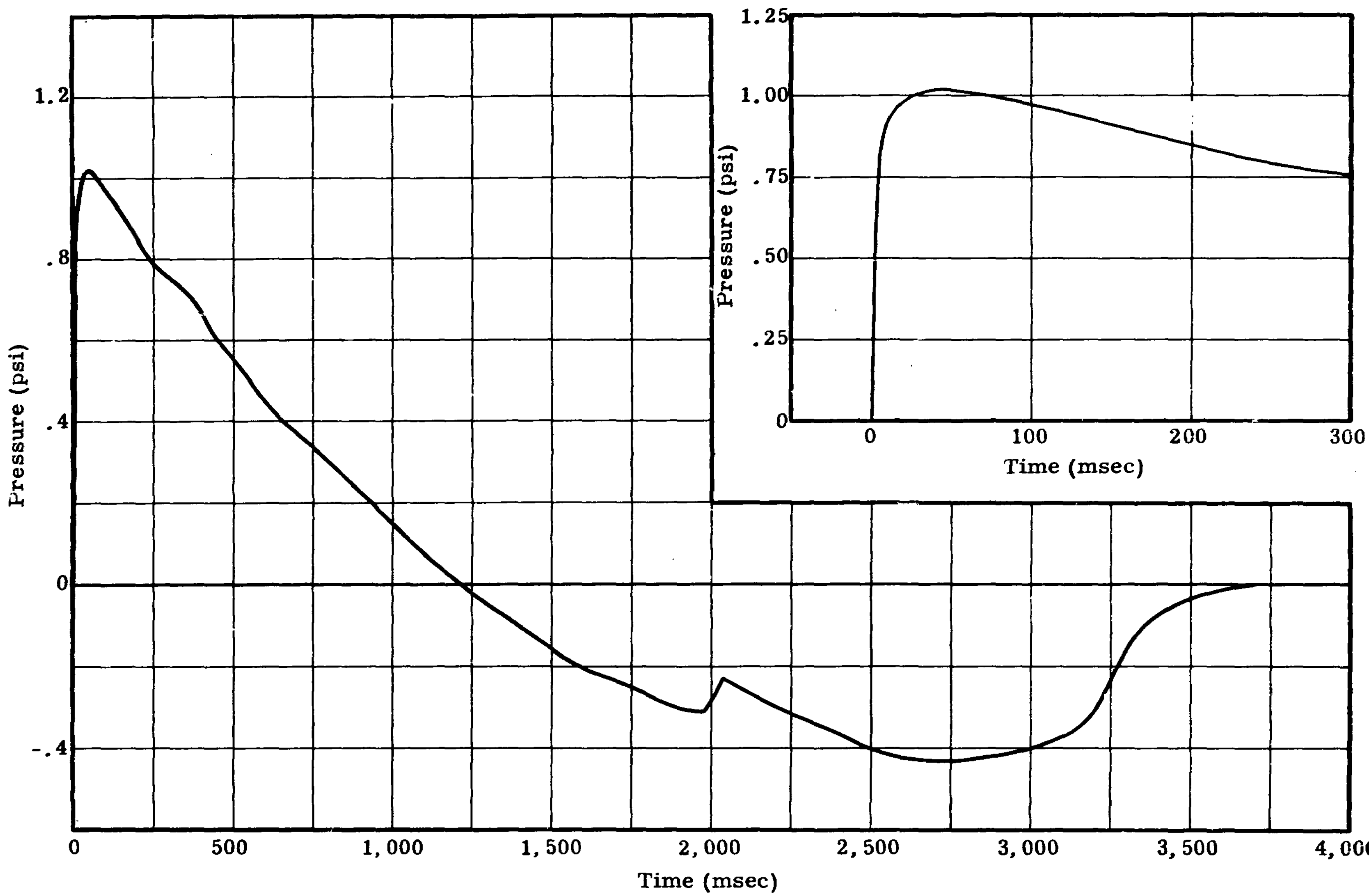


Fig. 13. -- Observed and predicted data from gauge 5 shot D

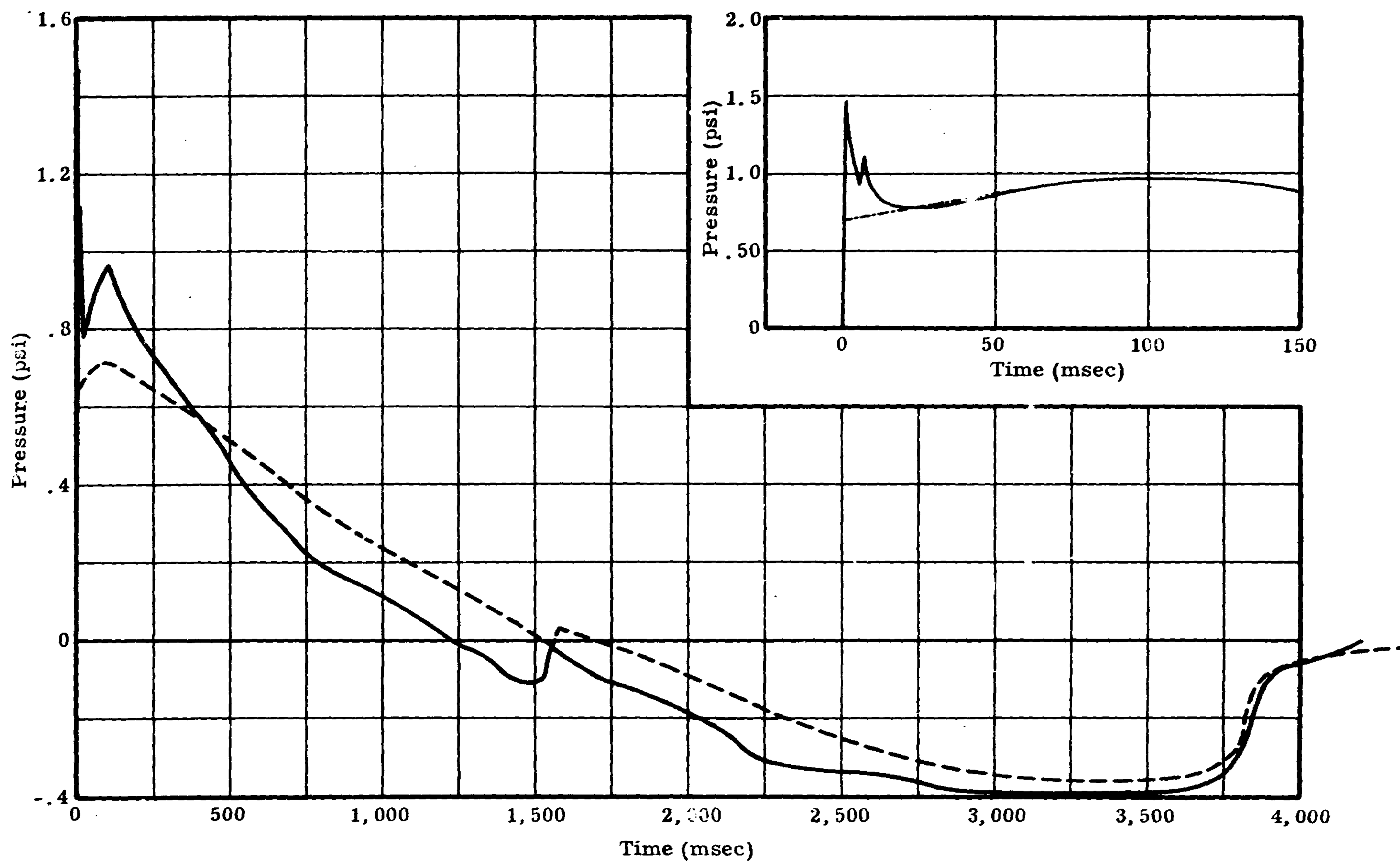


Fig. 14. -- Observed and predicted data from gauge 1 shot E

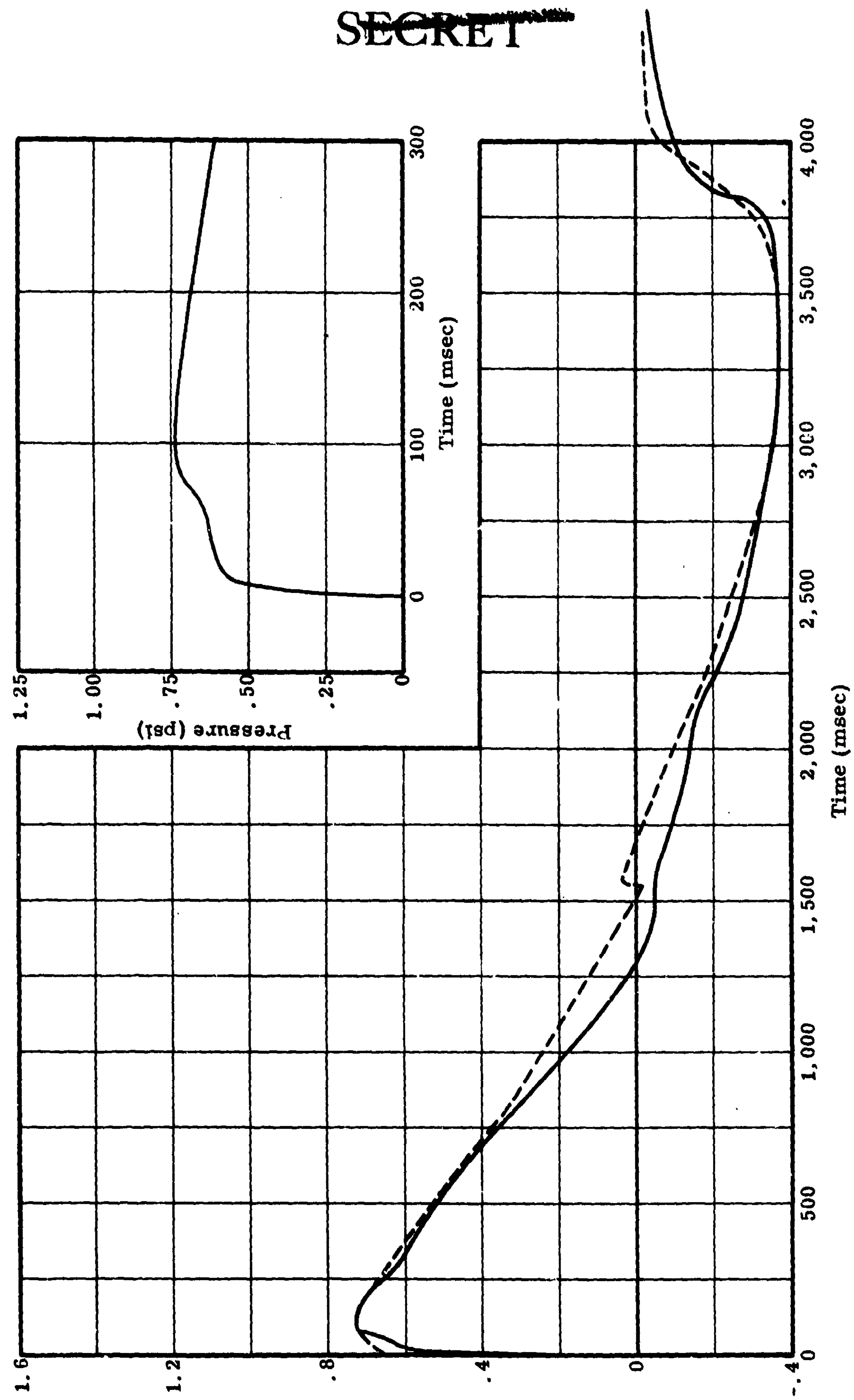


Fig. 15. -- Observed and predicted data from *gauge 2 shot E*

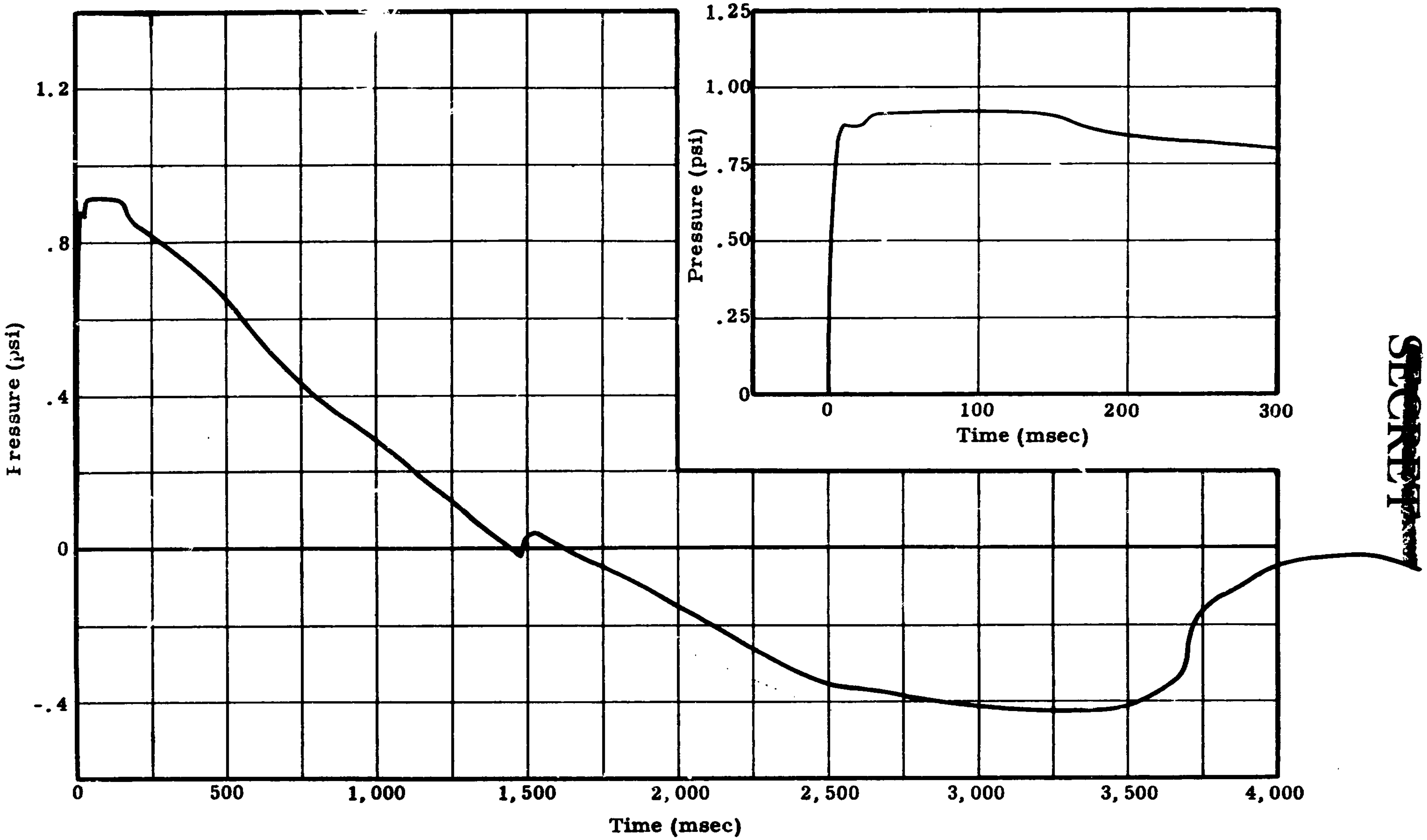


Fig. 16. -- Observed and predicted data from gauge 3 shot E

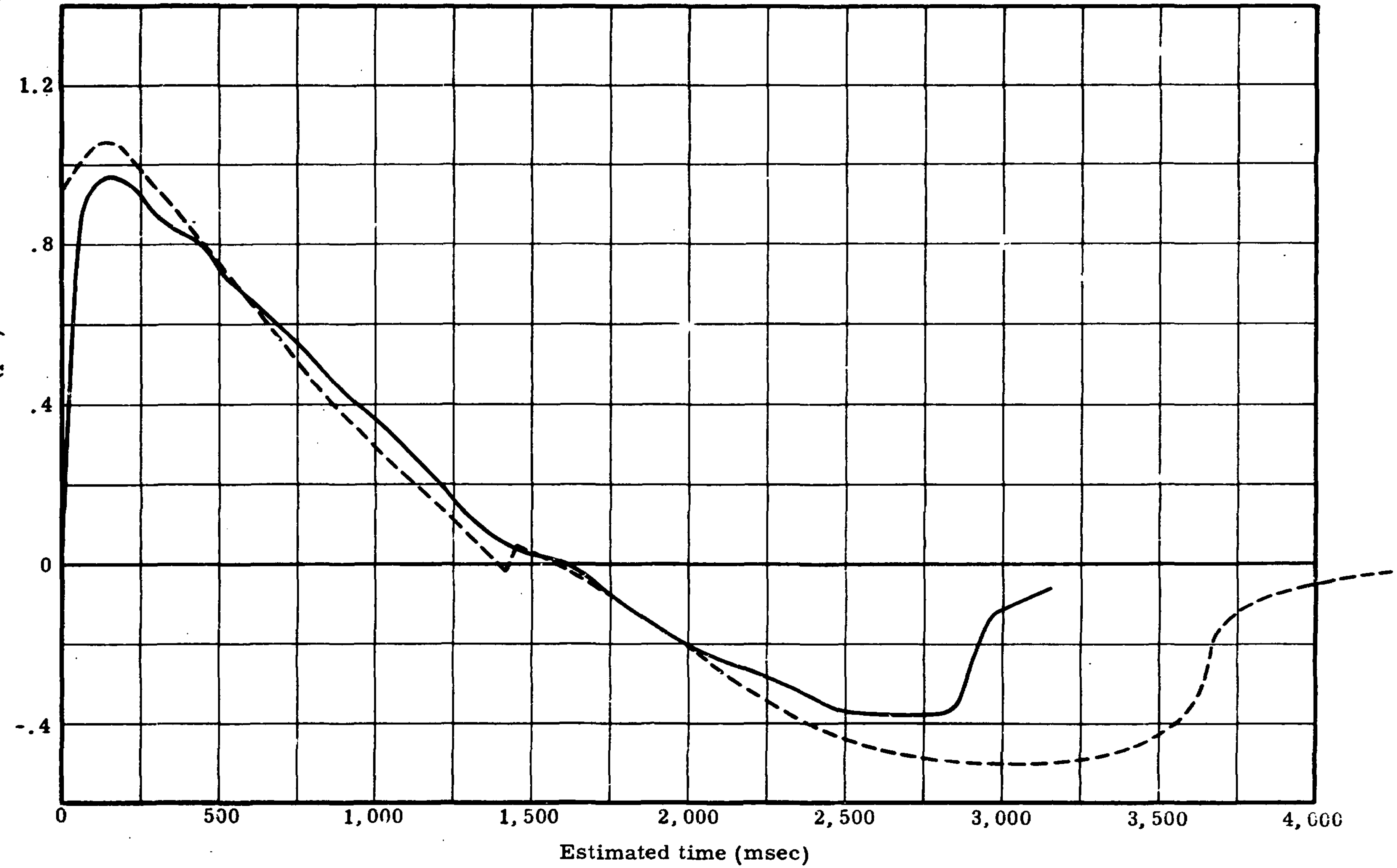


Fig. 17. -- Observed and predicted data from gauge 4 shot E

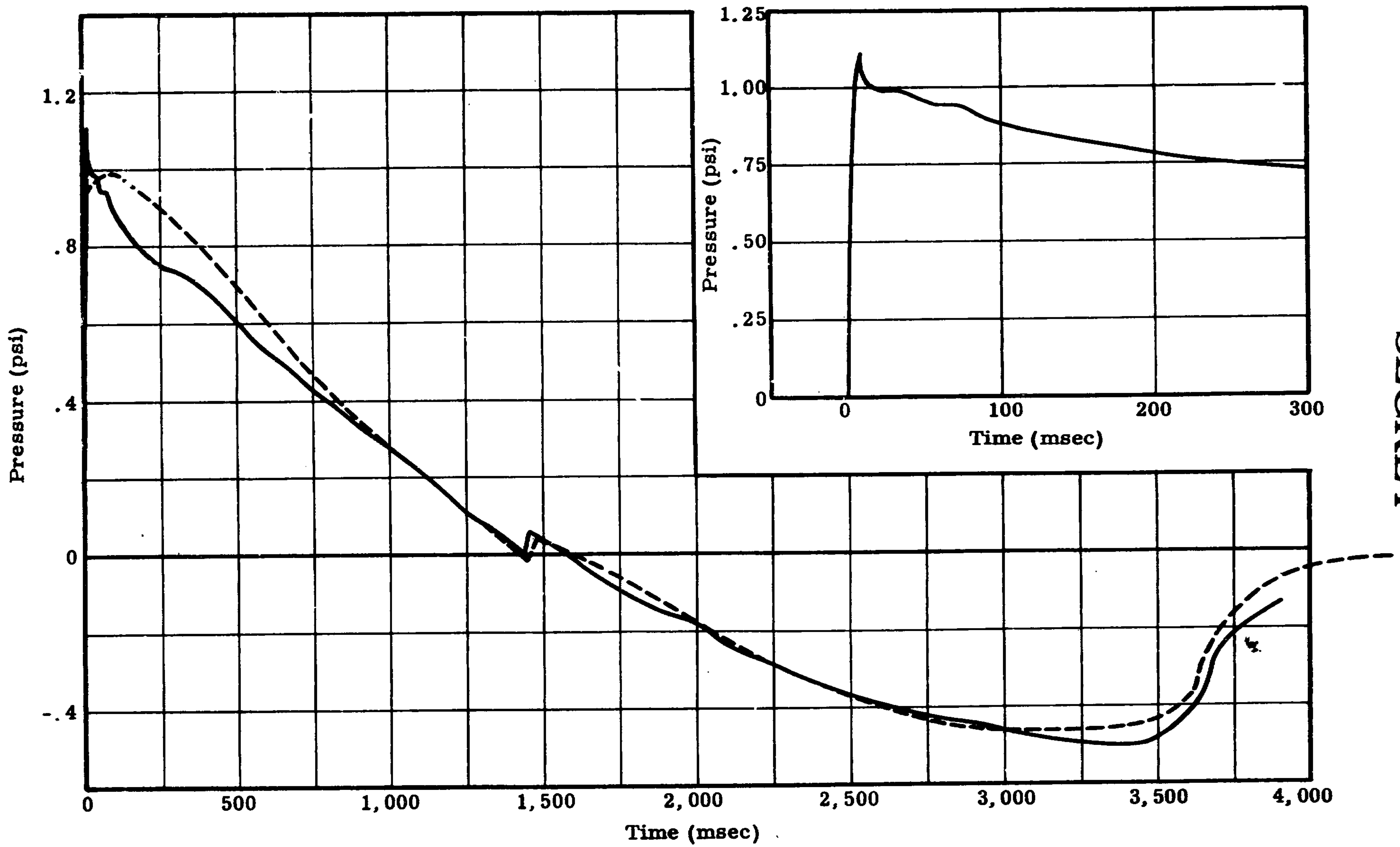


Fig. 18. -- Observed and predicted data from gauge 6 shot E

All gauges used in this series had calibrations of the order of 0.1 psi per fringe shift; thus a clear record can be read to an accuracy of ±0.025 psi. Not all were 'clear records'; C3* and D3 were dark, and E2 was quite light, but inaccuracies for these three records were probably not greater than ±0.05 psi. A check was made on all complete records to ascertain that the final pressure was nearly the same as the initial pressure.

The time scale was determined from millisecond timing marks put on the film at the same time as the record. These marks can be counted as accurately as human patience will allow, which usually means that in 1000 milliseconds an error of one or two may have accumulated. From two records, D3 and E4, the timing marks are lacking. The data from these are presented in Figs. 12 and 17 to a time scale estimated from the records of C3 and C4 (no time accuracy is claimed for these graphs). All times were measured from the shock fronts; relative times among the records and absolute times with respect to the time of detonation of the bomb are not known.

Predictions

These data were accumulated with the intent of finding the influence of ground features on the pressures recorded. It was therefore desired to estimate the pressures that would have been present at the positions of the gauges had the ground been flat. These 'predicted air pressures,' as they will henceforth be termed, were calculated by a method used before by this group and further simplified as justified for the relatively weak shocks.†

In Figs. 5-18 the broken lines show the predicted air pressures for positions other than the standard. Position 5 was established well out in the open to serve as a standard from which the predictions might be made. It was so used in shots C and D. As indicated in Table I, record E5 was missing; hence predictions for series E were made from E3.

Discussion of the Data

A conventional or textbook description of a blast wave tells of a sharp pressure front followed by a decrease in pressure to that of the undisturbed air and an overshoot into a long negative phase.[2] The records of these tests show air pressures of a much different character, particularly in their negative phases. The conventional wave has a negative phase (A, Fig. 19) which varies smoothly throughout.

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*This notation is used throughout this report; 'C3' or 'record C3' means the record from gauge 3 during shot C.

†See Appendix I to this report and also Appendix I of reference 7.

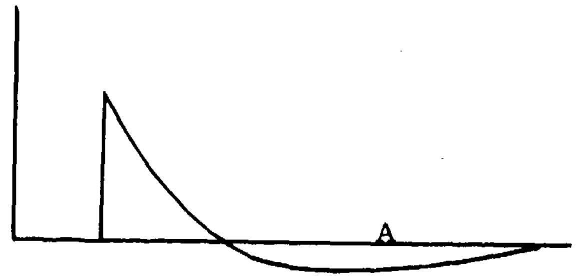

Fig. 19. -- Conventionalized blast wave

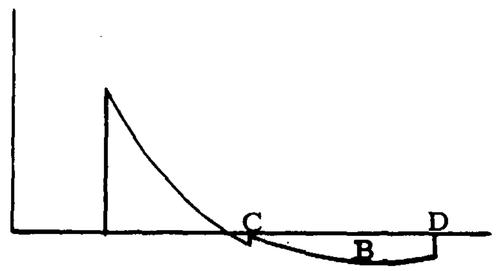

Fig. 20. -- Observed blast wave

The observed blast wave has an interrupted negative phase (B, Fig. 20). A small shock (C) is sometimes seen at the beginning of the negative phase; this second shock has been observed before.[3] The striking feature is the shock or near-shock (D) with which the negative phase ends. Certainly an 'after shock' is a phenomenon which should be expected; the same process which acts to steepen the front of an adiabatic wave into a shock would be expected to steepen the end of a conventional negative phase into a shock. Such shocks from shells and bullets have been observed,[4] the complete phenomenon being called a 'ballistic' or 'N-wave,' and there are numerous stories of blasts being heard from afar as two distinct sounds. By a fortunate coincidence the area which was instrumented for this series of tests turned out to be that in which the after shock was forming.

Some semiquantitative ideas of the effects of the ground features about the gauges can be gained by looking at the corresponding graph (Figs. 5-18).

Gauges 4 and 6 were set behind a hill to explore whatever shadow the hill might produce. Unfortunately the time scale for record E4 (Fig. 17) is missing, but the pressures measured are still good. Neither the positive nor negative peak pressures were as great (by 9-24 per cent) as predicted. Comparison C4, which shows the negative phase only, shows the peak negative pressure to be 10 per cent less than was expected. In records C6 and E6 (Figs. 10 and 18) after an initial peak which rises 12 per cent higher than predicted, the pressure drops below and tends to remain slightly lower than the predicted air pressure. All these results and those to follow are summarized in Tables II, III, and IV so far as they can be formulated quantitatively.

Gauges 3, 2, and 1 were set to explore the effect of a blast wave proceeding up a valley to and up a hill at the upper end. Comparisons C3 and D3 (Figs. 7 and 12) are of the negative phase only, D3 without a time scale. C3 agrees closely with the prediction, but D3 does not.

TABLE II

Summary results on pressures

Record	Distance (mi)	P+ (psi) Predicted	P+ (psi) Observed*	P+ (psi) Per cent differential	P- (psi) Predicted	P- (psi) Observed	P- (psi) Per cent differential
C1	3.62	.56	.85	52	23	25	9
C2	3.53				24	25	
C3	3.05				28	29	
C4	2.78				30	27	-10
C5	2.29		1.08			37	
C6	2.96	.72	.81	12	29	31	
D1	3.62	.58	.76	31	28	30	
D3	2.05				32	25	-22
D5	2.29		1.02			42	
E1	3.37	.72	.96	33	36	40	11
E2	3.27	.74	.72		37	37	
E3	2.80		.91			425	
E4	2.42	1.06	.97	-9	50	38	-24
E6	2.61	.99	1.11	12	46	50	9

*P+ (obs) for station 1 is pressure excluding the spike.

TABLE III

Summary results on times

Records	Positive duration (msec)			Negative duration (msec)			Total duration (msec)		
	Predicted	Observed	Per cent differential	Predicted	Observed*	Per cent differential	Predicted	Observed	Per cent differential
C1	1250	1030	-17-1/2	1820	2077		3070	3107	1
C2				1810	2080	15			
C3				1800	1800	0			
C4				1830	1780	-3			
C5		1100			1790			2890	
C6	1200	1120	-7	1810	1900	5	3010	3020	0
D1	1360	1150	-15-1/2	2100	2320	10	3460	3470	0
D3	No timing marks								
D5		1220			2030			3250	
E1	1520	1220	-20	2300	2580	12	3820	3800	0
E2	1510	1290	-14-1/2	2290	2510	10	3800	3800	0
E3		1460			2210			3670	
E4	No timing marks								
E6	1420	1440	+1-1/2	2180	2190	0	3600	3630	1

*End of negative phase is taken as the time the pressure turns up sharply.

TABLE IV

Summary results on impulses

Record	Positive impulse (psi-msec) Predicted	Positive impulse (psi-msec) Observed	Positive impulse (psi-msec) Per cent differential	Negative impulse (psi-msec) Predicted	Negative impulse (psi-msec) Observed	Negative impulse (psi-msec) Per cent differential
C1	323	298	-8	285	334	+17
C2				293	314	7
C3				330	355	-7-1/2
C4				378	287	-24
C5		506			448	
C6	388	336	-13	346	379	9-1/2
D1	366	329	-10	406	476	17
D3	No timing marks					
D5		600			632	
E1	564	500	-11		705	
E2	576	518	-10		7650*	
E3		696			7670*	
E4	No timing marks					
E6	744	670	-10		7750*	

*In these three the pressure had not returned to zero by the end of the record.

At position 2 results become more positive. In each of C2 and E2 (Figs. 6 and 15) the negative phase is considerably longer (10-15 per cent) than predicted. In E2 the pressure has risen more or less as predicted, but after 750 milliseconds the observed pressures drop below those predicted and continue so until well into the negative phase. The net result is that the positive impulse is smaller and the negative impulse larger than predicted.

Records from position 1 (Figs. 5, 11, and 14) are the most satisfactory of all, both in terms of completeness and in terms of signs of definite terrain effects. In each there is evidence of a Mach stem in the high spike at the beginning of the record. That a Mach stem should be present is evident from the physical configuration: the gauge measured pressures part way up an inclined plane, and just such a configuration is used by the Princeton[5] and the BRL[6] teams to produce stems. Note further that the ratio between the actual pressure at the peak of the spike and the pressure indicated by extrapolation excluding the spike is very close to two. These data are presented in Table V; the extrapolations are presented in inserts to Figs. 5, 11, and 14.

TABLE V

Record	P(spike)	P(extrapolated)	P(spike) / P(extrapolated)
C1	1.81	.85	2.13
D1	1.42	.75	1.89
E1	1.46	.70	2.09

These two circumstances lead one to attribute the initial spikes of records C1, D1, and E1 to Mach stems. The duration of the spike is 25-50 milliseconds. This time presumably depends on the position of the gauge on the slope; the nearer the gauge to the bottom, the smaller would be the anticipated effect of the slope and hence the shorter the duration of any such spike.

If the spike is excluded, the remainder of the observed pressure-time curve differs from the predicted curve in yet other respects. For the range 300-400 milliseconds the observed pressures are greater than the predicted pressures, while thereafter they are smaller. The positive impulse is nearly that predicted because the peak pressure is higher but the duration is shorter than predicted. Whereas the Mach spike is almost negligible because of its short duration, this 'hill effect' lasts almost the whole time of the wave.

In the somewhat different circumstance of diffraction of blast waves about man-made structures[7, 8] there has been noticed an apparent shortening of positive durations of the pressures on the front faces of obstacles. Of course the two cases differ in the very much smaller scale of the buildings in their rectangular cross sections, but it is interesting to note this further evidence of an effect not seen in shock tubes.

Conclusions

Because of the small number of satisfactory records, the results of this test series are few and fragmentary. Perhaps the most important finding is the evident need for additional work less ambitious in scope and more ambitious in detail.

There are vague indications that a hill will produce a shadow. The shadow seems to be very weak, as diffraction leaves the pressures there almost as strong as in the open. If this conclusion is correct, decrease in damage behind hills will be limited to borderline cases.

There is no evidence of a strengthening of the blast along this particular valley, but neither is there evidence against it.

There is a very definite hill effect. The stem formed on the hill's fore slope was of too short duration to damage any but the most fragile objects, but the change in shape of the remainder of the wave may have appreciable effects. For frames and structures where the times necessary to do serious damage are relatively long, the decrease in impulse may lead to an actual decrease in damage. For covering materials and building elements characterized by threshhold responses, the increase in pressure may lead to an increase in damage.

References

1. Buck, W. E. and Barkas, W. H., "A Recording Interferometer Gauge," Rev. Sci. Inst. 19, 678 (1948).

2. Effects of Atomic Weapons, prepared by the Los Alamos Scientific Laboratory, U.S. Government Printing Office, 1950, Section 3.11.

3. Curtis, W. E., Free Air Blast Measurements on Spherical Pentolite, Ballistic Research Laboratories memorandum report 544, July 1951.

4. DuMond, J. W. M., Cohen, E. R., Panofsky, W. K. H., and Deeds, E., "Determination of the Wave Forms and Laws of Propagation and Dissipation of Ballistic Shock Waves," J. Acoust. Soc. Am. 18, 97 (1946).

5. White, D. R., An Experimental Survey of the Mach Reflection of Shock Waves, Princeton University technical report II-10, August 21, 1951.

6. Shock Tube Photography, Ordnance Department, Ballistic Research Laboratories (no date).

7. Penzien, J., Experimental Investigation of the Blast Loading on an Idealized Structure, Sandia Corporation report SC-2124(Tr), December 13, 1951.

8. Merritt, M. L., Preliminary Study of Greenhouse Shock-Wave Diffraction, Sandia Corporation report Z-68823, September 13, 1951.

Appendix I to:
SOME MEASUREMENTS OF TERRAIN
EFFECTS ON BLAST WAVES

To predict the air pressure at a point farther from ground zero than that where the air pressure is known, an approximate method was used which combines the Riemannian form of the equations of fluid motion with the Rankine-Hugoniot equations of shock motion.

The Riemann equations describe the air flow behind a shock and were used to predict the change in shape of the air pressure curve. For moderately weak shocks diverging spherically these become

$$Q = \frac{5}{2} c - \frac{1}{2} u = \text{constant} = \frac{5}{2} c_0$$

$$N = \frac{5}{2} c + \frac{1}{2} u = N(\delta) \qquad (1)$$

$$\frac{\partial N}{\partial t} + (c+u) \frac{\partial N}{\partial r} = -\frac{cu}{r}$$

$$\delta = \frac{P - P_0}{P_0}$$

The meaning of these equations is that a pressure δ behind a shock front can be characterized by a function $N(\delta)$ that advances at the rate

$$\frac{dr}{dt} = c + u \qquad (2)$$

and at the same time decreases as

$$\frac{dN}{dt} = -\frac{cu}{r} \qquad (3)$$

If the pressure-time curve of a blast wave at one distance from the shot, $p(r_0, t)$, is known, the pressure-time curve at a greater distance $r = r_1 > r_0$ can be inferred. To each point $p(r_0, t_0)$ of the known curve there is a related point $p(r_1, t_1)$ on the predicted curve. The shock front travels at a rate of propagation $U < c + u$; its new position is marked on a graph, with the results of the application of equation 1, and that part of the pressure wave apparently in front of the shock is thrown away. Thus the progress of a wave may be traced as it goes away from the zero point, changing in shape and decreasing in maximum amplitude.

In these tests the overpressures are so small compared with the ambient air pressure ($\delta < .1$) that the process is much simplified by expanding the various formulae concerned into power series in δ. Thus to the second order

$$\frac{d\delta}{dr} = -\frac{uc}{r} \Big/ (c+u) \frac{dN}{d\delta}$$
$$= -\delta\left(1 + \frac{1}{7}\delta\right)/r \qquad (4)$$

and integrating

$$\delta = \frac{A}{r}\left(1 + \frac{1}{7}\delta\right)$$

$$= \frac{A}{r} + \frac{1}{7}\frac{A^2}{r^2} \qquad (5)$$

A little algebraic manipulation then yields

$$\frac{P_0 - P_1}{P_0} = \frac{\delta_0 - \delta_1}{\delta_0} = \left(1 - \frac{r_1}{r_2}\right)\left(1 + \frac{1}{7}\delta_1\frac{r_1}{r_2}\right) \qquad (6)$$

as a working formula for relating the pressure at a predicted point $P(r_1, t_1)$ to that at a known point $P(r_0, t_0)$ on an air-pressure curve.

For relating the predicted times, t_1, to the observed times, t_0, start with equation 3 in the form

$$dt = \frac{dr}{c + u} = \left(1 - \frac{3}{7}\delta - \frac{18}{49}\delta^2\right)\frac{dr}{c_0} \qquad (7)$$

Substituting equation 5, integrating, and manipulating gives

$$dt = \left(\frac{r_2 - r_1}{c_0}\right) - \frac{6}{7}\delta_1\frac{r_1}{c_0}\left(1 - \frac{1}{7}\delta_1\right)\left[\ln\frac{r_2}{r_1} - \frac{4}{7}\delta_1\left(1 - \frac{r_1}{r_2}\right)\right] \qquad (8)$$

In this treatment several approximations have been made in which the errors are very small because of the low overpressure levels concerned. The power series expansions were made by assuming that the Rankine-Hugoniot expressions for particle and sound velocity hold all through the shock wave and not merely at the shock front. This assumption differs from actuality only in terms of δ^3 and greater, all of which terms have been neglected in equations 6 and 8. In the expressions as they are left the second order terms are only 1 per cent or less of the first order terms.

A more serious error lies in the assumed sphericity of the wave. Estimate of this error is uncertain, but an idea of its magnitude can be gotten in realizing that the distance of the gauges from ground zero was about ten times the burst height and that the lateral spread of the gauges amounted to not more than 15 per cent of the distance of any gauge from ground zero. The predicted change in pressures from the standard was not more than 15 per cent and errors attributable to nonsphericity are of the order of 10 per cent of this decrement so that the net error amounts to less than 2 per cent.

Finally, predictions are no better than that curve from which they are made, and because the standard curves were taken to be good to $\pm$.025 psi, the indicated error in prediction from all sources is .025 psi plus 2 per cent of the pressure at any time.

SSTS 26 June 1995

MEMORANDUM FOR DEFENSE TECHNICAL INFORMATION CENTER
ATTN: OCD/MR. BILL BUSH

SUBJECT: Declassification of Report

The following reports have been reviewed by the Defense Nuclear Agency Security Office (ISTS):

Report No:	AD No:
AEC WT-606	467229
WT-1473	~~611262~~ u/2
WT-501	514221
WT-301	479248
WT-1109	~~617182~~ u/2
WT-1103	~~611254~~ u/2
WT-1108	~~611321~~ u/2
WT-1101	~~460280~~ u/2
WT-1102	~~611253~~ u/2
WT-1407	~~452637~~ u/2
WT-1110	~~617155~~ u2
~~WT-602~~	~~356274~~ completed
DASA WT-1403	~~611257~~ u2
WT-1614	355492
WT-1155	~~617170~~ u/2
POR-2280	345753
WT-9003	~~342207L~~ u/2
WT-1501	~~350279~~ replaced by AD-490150 ST-A now

The security office has **declassified** all of the listed reports. Further, distribution statement "A" applies to all of the reports.

FOR THE DIRECTOR:

(S)

JOSEPHINE B. WOOD
Chief, Technical Support

Security

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